Application of Technology to Transportation Operations in Biohazard Situations

Task 5: Transportation Activities and Applications of Technology

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Table of Contents

1. Executive Summary 1

2. Background 3

3. The Role of Transportation Agencies in Biohazard Situations 3

3.4.1. Restricted Mobility & Access 8
3.4.2. Delivery of Prophylaxis 9
3.4.3. Evacuation 9
3.4.4. Other Transportation Logistics 10

4. Evaluation of Technology Options 12

4.1.1. Surveillance / Detection 13
4.1.2. Communications 15
4.1.3. Traveler Information 17
4.1.4. Environmental Management 19
4.1.5. Traffic Management 19
4.3.1. Availability of Technologies / Emerging Technologies 34
4.3.2. Matrix: Assessment of Equipment Needs & Specifications for Preferred Options 35

5. Conclusions & Recommendations 55

List of Figures

Figure 1: Applicability of ITS and Communications Technologies to Major Transportation Activities During a Biohazard Incident 2
Figure 2: Matrix of Tactical Operations & Management Activities vs. ITS Technology 22
Figure 3: Assessment of Equipment Needs & Specifications for Preferred Options 36

1. Executive Summary

In the wake of the attacks of September 11th, 2001, the transportation community has been proactively assessing the role of transportation during emergency situations. Prior to 9/11, most of the focus on transportation's role was on weather-related incidents such as hurricanes. Transportation agencies that faced the threat of severe weather events could depend on sophisticated tools to determine the effects of such an incident on the management and operations of the transportation system. These tools helped inform transportation planning for evacuations and system recovery, activities for which advance warning was often available.

Since 9/11, however, transportation agencies have shifted their attention to the wide range of potential terrorist strikes that could occur without notice and that would require immediate, coordinated response efforts. In particular, a biohazard emergency presents transportation challenges that are potentially even greater than those posed by a large-scale evacuation. A biohazard situation is unique in that it could simultaneously require minimizing mobility (e.g., preventing the movement of exposed populations or preventing access to a contaminated area) and maximizing mobility (e.g., facilitating the passage of first responders and medical supplies or maintaining mobility around a quarantine area).

The goal of this project, Application of Technology to Transportation Operations in Biohazard Situations, is to develop a more comprehensive and actionable understanding of the role of transportation during a biohazard situation so that communities can better plan for, respond to, and recover from such a situation. Earlier phases of this project consisted of a literature review and a scenario-based workshop. These phases generated insights that were used to develop an operational concept for transportation operations in biohazard situations. The operational concept describes the emergency management framework and how state departments of transportation (DOTs) fit into that framework. It then outlines the activities that a state DOT could be asked to perform before, during, or after a biohazard event.

This technology application plan builds off of that operational concept. This plan assesses the activities laid out by the operational concept and identifies the communications and Intelligent Transportation Systems (ITS) technologies that can assist state DOTs in carrying out those activities. Figure 1 shows the major types of response actions likely to be performed by a transportation agency during a biohazard event and the technologies that can assist the agency in executing those actions.

This plan then lays out functional requirements and specifications for these technologies that will ensure that the technologies perform their expected role during a biohazard event. Finally, this plan recommends a set of technologies that would be especially useful during a biohazard situation.

Figure 1: Applicability of ITS and Communications Technologies to Major Transportation Activities During a Biohazard Incident

Technologies	Emergency Communi-cations	Initial Identification, Verification, & Response	Restricted Mobility & Access	Traffic Management Around Affected Area	Public Information
CCTV Cameras		●		●	
Video Image Processing		●		●	
Roadway Detectors		●		●	
Infrastructure Monitoring Sensors		●			
Vehicle Probes		●	●	●	
Video Wall		●		●	
Mobile Communications	●	●			●
Mobile Data Terminals	●	●			
Computer Aided Dispatch	●	●			
Center-to-Center Communications	●	●			
Center-to-Field Communications	●	●			
Emergency Alert System	●	●			●
MayDay System	●	●			
Variable Message Signs		●	●	●	●
Highway Advisory Radio		●	●	●	●
511 Traveler Information			●	●	●
Trailblazing Signs			●		
Parking Lot Information Systems				●	●
Bus/Train Arrival Signs			●	●	
In-Vehicle Navigation Systems			●	●	○
Information Kiosks			●	●	●
Environmental Detectors		○			
Road Weather Information Systems		○			
Automatic Gate Systems			●		
Advanced Traffic Controllers			●	●	
Signal Preemption Technology		●			
Alternate Signal Control			●	●	
Advanced Transportation Management Systems		●		●	
Variable Speed Limit Signs				●	
Ramp Meters			●	●	
Electronic Toll Collection			●	●	
Lane-Use Control Signs/Reversible Lanes		●	●	●	

● = current application; ○= future application

2. Background

The transportation system can play several important roles in a biohazard emergency. Not only can the transportation system be used to facilitate the response to a biohazard emergency, but also it can also be the target of a biohazard attack, cause an accidental release of a biological agent, or facilitate the spread of a naturally occurring biological agent.

The transportation system is seen as a target for a deliberate release for at least two reasons. First, large numbers of people congregate at transportation facilities such as rail and subway stations, bus stops, and ferry and airport terminals. Second, an attack aimed at the transportation system could potentially cause serious economic harm by disrupting the flow of people and goods.

The transportation system is vulnerable to an accidental release because a traffic accident involving vehicles used to move biohazard materials could cause the release of biohazards. The transportation system can also contribute to the spread of naturally occurring bioagents, because of the high concentrations of people and goods at transportation facilities and the geographic reach of modern transportation systems.

Transportation technologies can greatly facilitate the response to a biohazard emergency and help to diminish the severity of a biohazard incident. The role of transportation technology in a biohazard emergency can include:

- Helping emergency responders communicate among themselves and with the public;
- Monitoring and surveying damage in order to coordinate an appropriate response; and,
- Facilitating or restricting the movement of people and goods in and around the incident.

3. The Role of Transportation Agencies in Biohazard Situations

To adequately plan for and respond to a biohazard situation, transportation agencies should recognize that differences exist in the planning and response to biohazard situations depending on the mode involved. Transportation modes to consider include highway, mass transit, aviation, rail, and maritime. This document focuses on highway and mass transit modes, because they are the modes in which state transportation agencies are likely to play the most significant role during a biohazard emergency. However, state transportation agencies should also be aware of the interconnections between all modes of transportation. During an event, biohazards may spread among transportation modes, as passengers, freight, livestock, agricultural products, and mail move across the different modes.

Highways

Highways consist of roads, tunnels, bridges, rest areas, and other infrastructure used for surface transportation. Although highways do not consist of enclosed areas with large numbers of people as is found with other modes, they do play a significant role in the spread of biological agents. Highways are vulnerable to biohazards because:

- Roadways can re-suspend contaminants that have settled out of the air;
- Rest areas can spread disease between travelers;
- Roads can be used to spread diseases among states and regions;

- Porous road surfaces are difficult to decontaminate;

- Travelers may traverse a contaminated roadway unknowingly, thus becoming a carrier or victim of the biological agent; and

- Freight, livestock, agricultural products, and mail transported on highways can spread biological agents.

Mass Transit

Mass transit systems include buses, subways, light rail, monorail, or other ground-based public transportation and associated stations, tracks, tunnels, bridges, and other infrastructure used by large numbers of people. Unlike highways, mass transit is less likely to spread disease between regions because individual transit systems are generally bounded by city or regional limits. Because of this, the spread of disease may be contained and limited if identified quickly. However, mass transit is typically interconnected with other modes of transportation, such as highways, aviation, and rail, that span different geographic regions. These interconnections may lead to the spread of disease beyond a geographic region as infected passengers move from mass transit onto these other transportation modes. Once authorities identify a biohazard situation in a transit system, the system can be shut down and decontaminated while travelers are quarantined and given prophylaxis. However, within city or regional boundaries, transit systems are susceptible because:

- Transit systems include a large number of enclosed spaces such as tunnels, stations, terminals, and passenger compartments;

- Contamination can be persistent and can pervade heating, ventilation, and air conditioning (HVAC) systems; and

- Disease can spread to connecting transit systems and modes.

Modal Interconnectivity

Other modes of transportation include aviation, rail, and maritime. Although these modes are not the focus of this report, the interconnectivity of these modes with the highway and mass transit modes will play an important role in emergency preparedness and response, including the selection and implementation of ITS systems. Passengers, freight, livestock, agricultural products, and mail are commonly transported using multiple modes of transportation. As they move from one transportation mode to another, biological hazards may also spread with them. The use of ITS to monitor and control the flow among transportation modes and the points of interconnection between these modes may help prevent an intermodal transfer of biological hazards.

3.1. Awareness, Prevention, & Preparedness Activities

Prior to a biohazard situation, transportation agencies should have polices and procedures in place that can be used to provide a more effective and efficient response when a biohazard incident occurs. Transportation agencies should engage in the following activities in order to increase awareness, prevent, and prepare for biohazard emergencies:

- Establish working relationships between stakeholder agencies through participation in task forces and regular meetings. Relationships should be established prior to an incident in order to facilitate a coordinated response when there is an incident. Incident responders should know who the agency stakeholders are and have their contact information, thus improving notification and response time.

- Establish protocols and systems for stakeholder identification. Having 24/7 event notification protocols, call trees, single-point of contact notification systems and agency as well as stakeholder-wide communications systems improves notifications and response time.

- Establish protocols for heightened Homeland Security Advisory System threat levels. Protocols help to keep all stakeholder agencies aware of threat conditions and may help to prevent incidents from occurring.

- Develop incident response and after-incident recovery plans. These plans provide a roadmap to guide and coordinate stakeholder agencies during and after an incident. It also helps to define the roles of each agency in the response to and recovery from an incident.

- Develop and coordinate evacuation plans. These plans provide stakeholder agencies with one consistent method for moving people from an affected area quickly and safely.

- Develop an incident command structure. This helps to establish what agency is in charge of organizing the response and making decisions. It also helps to define the roles and responsibilities of each stakeholder agency.

- Develop an Intelligent Transportation System (ITS) Architecture. The ITS Architecture defines the functions, systems, and information and data flows required for an integrated response.

- Develop policies to facilitate institutional coordination, communication, and information and resource sharing, including agreements for shared operations or a clearinghouse of information. Developing these agreements prior to an incident helps to remove any barriers that may exist between agencies and allows stakeholders to work together more easily.

- Conduct multi-agency biohazard incident response and recovery training and exercises. Completing biohazard training and exercises helps educate stakeholders and provide them with hands-on experience of what to do when there is an incident. Completing training and exercises will ultimately help stakeholders respond to incidents better and in a more timely fashion.

- Model the transportation network using simulated conditions. Modeling of the network using possible scenarios that may be present during an incident helps stakeholders to determine what the best strategies are for improving the flow of traffic on the network when an actual incident occurs.

- Develop an up-to-date inventory of transportation resources and a plan for deployment of resources during an incident. An inventory of transportation resources helps agency stakeholders determine what equipment is available for responding to an incident.

- Develop a plan for biohazard waste removal and decontamination of people and equipment. Having a plan for this ahead of time helps to reduce the time of exposure, speed up the decontamination process and reduce additional contamination because of improper handling / disposal of biohazard waste.

- Establish requirements for security at special events. Improving security at special events will help to deter possible incidents as well as detect those incidents more quickly.

- Deploy additional ITS systems, equipment, and infrastructure. Additional ITS technology can be used to prevent or detect possible incidents. For example, CCTV cameras can be used to identify suspicious activity and detect incidents more quickly, which can allow a more accurate response that is based on the type of incident.

- Consider the needs of special populations (disabled, elderly, school children, inmates) during a biohazard incident. During an incident, certain populations are more vulnerable because they do not have the capability to move freely away from an incident. Therefore when planning for an incident, these populations need to be taken into account.

3.2. Communications

Central to response in biohazard situations is communication. Communication not only includes voice commands, but also center-to-center communications for the sharing of data and video, center-to-field communications for the sharing of data from the field, and communication from sensors and mitigation devices. Emergency responders, law enforcement, traffic and incident management centers and other transportation officials need to have a common method for communicating in order to effectively manage the personnel and supplies required for responding to a biohazard incident. The following steps should be taken to prepare for a biohazard incident:

- Develop and test the interoperability of emergency communications system. An interoperable emergency communications system is essential so that all responding agencies can communicate.

- Establish direct electronic connectivity between all stakeholder agencies and operations centers, including transportation management centers (TMCs) and emergency operations centers (EOCs). Direct electronic connectivity can facilitate the movement of information, data, and incident images between stakeholders and allow stakeholders to better respond to incidents.

3.3. Initial Identification, Verification, & Response

Before the response to a biohazard event can even occur, it must be identified and verified. Once this has occurred, all stakeholders can be notified, a response plan can be initiated, and the initial response can commence. The following activities are part of the initial identification, verification, and response to a biohazard incident. Biohazard events may not have an immediate effect. An incident may be detected immediately, or it may only be discovered when exposed individuals begin exhibiting symptoms days or weeks after the initial release of the agent.

Due to the potentially long timeframes between the release of a biohazard and its identification, the activities listed below may not occur in the order in which they are listed. For example, some emergency response activities may occur to assist victims or control the spread of disease before the particular biological agent has been positively identified. The time between initial release of a biohazard and its detection may indicate the geographic impact of the incident and the needed response. An incident that is quickly detected is more likely to be contained than one that is discovered days or weeks after the release:

- Verify the incident. Before notification begins, stakeholder agencies should verify the type of incident, the severity, and the type of response warranted. This can be done by assessing 911 reports, sending personnel to the site, or using detection equipment. If a biohazard incident causes an immediate physical reaction by the people in the vicinity of the incident, CCTV cameras can also be used to visually verify the incident.

- Dispatch emergency responders. Emergency responders must be dispatched to the incident to provide medical services, contain the incident, and provide an assessment of the transportation network. This assessment is important for determining where infrastructure has been contaminated and where the network needs to be closed. In addition, it can be used to help develop alternate routes around the incident.

- Classify the incident. In order to determine the level of response necessary (local, state, federal), the incident should be classified using the Emergency Activation Levels. Doing so helps to inform all stakeholder agencies of the severity of the incident using a single format for classification.

- Activate protocols for stakeholder notification. Quick notification of all applicable stakeholders helps to improve response time and may shorten the duration of the incident.

- Activate the incident command structure. Activation of the incident command structure assigns roles and responsibilities to all stakeholder agencies.

- Activate the Emergency Operations Center (EOC) and assignment of personnel to the center. Activation of the emergency operations center provides a place for agency stakeholders to coordinate and a point of contact for stakeholders to get incident information. Assigning stakeholder personnel to the EOC helps to keep all agencies coordinated, informed, and involved in the response.

- Activate incident management and evacuation plans. Incident management and evacuation plans outline the strategies and procedures for stakeholders to follow to most effectively handle the incident.

- Initiate statewide communications system. Use of a common communications system is crucial during an incident so all stakeholders can communicate with one another.

- Activate shared operations protocols. Shared operations allow multiple agencies to view and control field equipment, including variable message signs, detection equipment, CCTV cameras and highway advisory radio. Doing this allows all stakeholder agencies to have access to the best and the same information available, including information regarding the type and severity of the biohazard incident and the measures being used to respond to the incident..

- Notify bus, railroad, and trucking companies, aviation authorities, and other transportation agencies. These companies need to be informed so they can either suspend service for the affected area or alter their routes.

- Initiate protocols for special populations. Protocols may need to be implemented for the transportation, protection, and care of special populations. School children may need to be delivered to their parents rather than to their homes. The elderly and disabled may need help evacuating, especially if a nursing home is threatened by the incident, and prison inmates may need to be moved to another secure location.

- Coordinate assets, resources, and equipment for a multi-agency response based on the incident assessment. In order to provide the best response to an incident, agency stakeholders must pool their assets, such as equipment and personnel, and determine how and where to best use each.

- Identify key transportation facilities that will be used during the incident. Key transportation facilities such as parking lots can be used as staging areas and for parking or storage of emergency vehicles. Other important facilities include vehicle repair and service facilities.

3.4. Transportation System Management and Control

Management of the transportation system can be significantly different based on the type of biohazard incident that occurs. Some types of biohazard incidents may require evacuation, while others may require a different response, quarantine, which requires restricting mobility and access. Therefore, different transportation management strategies are necessary for each type of response.

3.4.1. Restricted Mobility & Access

Restricting mobility and access during a biohazard incident is important for preventing the further spread of disease and to re-route travelers around the affected area. The response, however, depends on the scale of the biohazard incident and the area affected. If a small area were affected, transportation officials might impose a quarantine, close the roads entering the area, set up checkpoints for entry and exit, suspend transit service to that area, and re-route through traffic around the incident. If an incident were statewide, transportation officials might do these same things on a larger scale as well as suspend intercity passenger rail service, close airports and ports, reconfigure freight routes and re-route traffic through bordering states. The following are transportation management and operations activities that should occur during a biohazard incident:

- Establish and manage emergency access. Barricades and gate systems establishing emergency access are needed in order to prevent the public from entering the affected area and to allow emergency responders access.

- Detour traffic around the quarantine area and provide road closures and other incident information to local residents. Local residents who are outside of the quarantined area must be informed of the situation so they do not try to return to their homes.

- Use ramp controls to close ramps to highways in the affected area.

- Use alternate traffic control. Alternate signal timing plans can be implemented in order to accommodate the change in traffic flow patterns due to the incident. Signal control and timings can be adjusted to account for closed highway ramps and to adjust for a greater amount of traffic on both freeways and arterials surrounding the quarantined area.

- Provide buses for transit users outside the affected area to reach their destination if transit lines are closed or the service is suspended.

- Coordinate delivery and security of resources for the public to the affected area including food, water and supplies and monitor the flow of these goods to ensure sufficient supplies are available. Stakeholders must ensure that although the affected area is cut off to traffic and deliveries that the affected public still receives the necessary supplies.

- Use spare transit vehicles or transportation vehicles to deliver supplies into the quarantined area.

- Institute peak spreading. For long term incidents that close part of the transportation network, stakeholders can encourage peak spreading in order to reduce the strain on the open sections of the transportation network during the normal peak hours.

- Limit the use of the transportation network. Work hour restrictions, curfews, and voluntary "snow days" can be used to discourage the use of the network by the public.

- Close ports and airports, suspend transit and intercity rail services.

3.4.2. Delivery of Prophylaxis

Although transportation agencies cannot assist with the medical treatment of affected individuals, transportation management and operations activities can be used to help facilitate the movement and delivery of medical supplies, such as vaccines and antibiotics, to the affected area in a timely manner. Strategies for doing this include:

- Coordinate with shippers and suppliers to determine the time required to procure and deliver prophylaxis to the affected area.

- Provide secure routes for the delivery of critical goods and emergency supplies

- Coordinate between transportation management centers, Federal agencies, and public health officials to monitor the route and movement of the delivery truck from origin to destination.

- Support the local distribution of vaccines and antibiotics by public health officials.

- Expedite the delivery of prophylaxis by using lane use control signs to close a lane (for use by prophylaxis delivery trucks only).

3.4.3. Evacuation

During an evacuation, transportation agencies must play a vital role in ensuring that the evacuation is efficient, timely, and safe. To reduce congestion and keep traffic moving away from the affected area, the following strategies can be implemented:

- Utilize ramp controls and metering. The ramp metering rate can be set to flush out the network or can be set to space cars farther apart in order to improve traffic flow during an evacuation.

- Use alternate traffic control. Alternate signal timing plans can be implemented in order to accommodate the change in traffic flow patterns due mass evacuation.

- Use variable speed limits. Variable speed limits can be used to lower the speed limit during highly congested evacuation conditions in order to reduce the possibility of secondary incidents.

- Encourage proactive diversions between networks. Promoting diversions during an evacuation can help to reduce gridlock and even out the flow of traffic on the main evacuation route.

- Encourage mode shift to mass transit by providing mass transit rail cars or buses for "rapid transit" as an alternate means for evacuation. Encouraging the public to change modes can help reduce the congestion and strain on highway evacuation routes.

- Modify roadway capacity by reducing capacity restrictions. Open HOV / HOT lanes and shoulders to general traffic to reduce congestion and facilitate movement of the public away from or around the affected area.

- Use multimedia communications to augment traffic and disseminate information.

3.4.4. Other Transportation Logistics

The following strategies may also be applied during biohazard incidents. The implementation of these strategies will depend on the nature of the event and the needed response:

- Close contaminated roads, transit lines, and infrastructure as well as parts of the transportation network not contaminated but located in the affected area.

- Deploy portable ITS equipment to monitor the incident and the response, as well as to monitor and route traffic around the incident. Portable ITS equipment can be used to monitor the situation and provide traveler information to the public.

- Implement strategies to facilitate access to the scene and to medical facilities by emergency responders. These strategies include dedicating highway lanes for emergency responders, providing preemption on arterials for roadways that emergency responders are using to access the scene, or closing roads to allow for emergency responder use only between critical points such as the scene and medical facilities.

- Implement transportation contracts and emergency procurement capabilities. Transportation contracts can be used for hazardous materials clean-up and emergency highway repairs. Emergency procurement capabilities can be used to replace equipment or infrastructure damaged by the incident.

- Route traffic and coordinate transportation service (spare transit vehicles) to bring affected citizens and the worried well to medical facilities. Traffic should be routed to facilitate access to medical facilities so that the affected can get to the facility for treatment.

- Keep neighboring jurisdictions informed of the status of the incident and coordinate traffic control strategies with them. Keeping neighboring jurisdictions informed of the status of the incident helps them to understand the change in traffic patterns. Additionally, they can make changes to their traffic control strategies to handle variations in traffic flow and communicate traveler information to the public via their field devices.

- Manage wide-area transportation around the affected area. Management of wide-area traffic (state or region-wide) around the incident helps to ensure that traffic keeps moving on alternate routes and evacuation routes.

- Monitor traffic flow in real-time. Real-time surveillance can be used to monitor traffic conditions and spot secondary incidents.

- Provide pre-trip incident, alternate route, and travel time information. This pre-trip information (via the Internet or 511) helps the public to avoid the incident area and determine the best routes for their trips.

- Provide incident, alternate route, and travel time information en-route. Providing Incident information en-route (e.g., via Highway Advisory Radio or variable message signs) allows the public to adjust their routes to avoid the incident.

- Provide “next-bus” arrival information en-route to help the public determine the best transit route to take.

- Provide trip planning capabilities for all transportation modes. Trip planning (via the Internet or kiosks) helps encourage travelers unfamiliar with a particular mode or alternate route to determine how to reach their destination.

- Provide traveler information for commercial vehicles and shippers. Traveler information for commercial vehicles and shippers helps them to route traffic around incidents, away from congestion or to encourage mode shifts.

- Coordinate with shippers and suppliers to determine the time required to procure and deliver resources to the affected area. There may be a lack of resources due to delivery problems associated with accessing both the affected area and the area surrounding the affected area due to the congestion caused by the incident. Therefore, stakeholders must coordinate with suppliers to ensure shipments are delivered in and around the affected area.

- Waive permits to expedite the transport of high-priority materials to and from the contaminated site. Expediting the movement of high priority materials to and from the contaminated site will help get the site cleaned up quicker.

- Collect and disseminate data from detectors. These data can help keep stakeholders up to date on the status of the transportation system and the presence of secondary incidents.

- Monitor for secondary incidents. Surveillance of the transportation network will provide a way to detect secondary incidents and monitor congestion.

- Provide spare transit vehicles for the transport of infected patients as well as dead bodies to medical facilities.

- Perform damage assessments. Although damaged infrastructure has already been closed, further assessments should be completed once the incident has been cleaned up in order to determine what needs to be done to repair the infrastructure.

- Perform infrastructure repairs. Once assessments have been made, infrastructure repairs can begin in order to get the transportation network back to normal conditions.

- Perform decontamination and waste disposal. Vehicles used in responding to or cleaning up the incident should be decontaminated and wastes must be properly disposed of in order to reduce further contamination.

- Organize transportation and facilitate the movement and proper disposal of wastes. This includes using transportation vehicles for the transport of contaminated materials and the restriction of traffic on the route between the affected area and the disposal site.

- Restore the transportation system to full operation. Once the incident has been cleaned up and infrastructure repairs have been made, normal operations of the transportation network should be restored.

3.5. Public Information

Another important activity during a biohazard emergency is to keep the public informed about the situation. During many incidents, this may include providing transportation information such as closed routes, alternate routes, and suspended services. However, in some cases it may be critical to also provide information to the public about how the incident may affect public health. Therefore, transportation, public health, and other officials must work with the media to inform the public:

- Provide information to the general public on the nature of the incident, precautions to take, restrictions, closed roads or other infrastructure, duration, treatment for exposure, and long-term consequences of the incident. Information must be provided to the public to help reduce panic and to assist in travel planning.

- Update information for the general public (via press releases) regarding the status of the incident and of the transportation system. Keeping the public up-to-date on the status of the incident helps to reassure and maintain public confidence.

3.6. After-Incident Evaluation

After the incident has been cleared and all damaged infrastructure has been repaired, transportation, emergency response, public health, and other involved agencies should review the entire incident. The following activities should occur:

- Assess the response to the incident. After the incident is over, conduct a review of the incident response procedures and protocols used in order to determine if any changes should be made for response in the future.

- Assess detour routes. Determine if the routes used were adequate, whether additional routes should have been use, and how traffic can be detoured more effectively in the future.

- Revise and update evacuation and incident response plans based on the lessons learned from their use for the incident in order to provide a better response in the future.

- Obtain copies of lessons learned documents from other agencies. Use these documents to determine if transportation could have facilitated a better response or been utilized more effectively.

4. Evaluation of Technology Options

Biohazard emergencies can happen anywhere in the transportation system. Deliberate attacks can occur in subway stations, natural occurrences can be spread via airline passengers, and accidental releases can result from a traffic accident. Because the transportation system is vulnerable to biohazard incidents, it is necessary to rely on technology to assist in the detection and verification and response to incidents.

4.1. Identification of Technology Options & Their Application to Biohazard Incidents

Based on the activities and strategies identified previously, there are a variety of technology options that transportation agencies can use to support a biohazard response. The following list provides the categories of options available:

- Surveillance / Detection
- Communications
- Traveler Information
- Environmental Management
- Traffic Management

4.1.1. Surveillance / Detection

Surveillance & Detection Technologies
▪ CCTV Cameras ▪ Video Image Processing ▪ Roadway Detectors ▪ Infrastructure Monitoring Sensors ▪ Vehicle Probes ▪ Video Wall

Closed Circuit Television (CCTV) Cameras can be used everyday for traffic management as well as for incident management during a biohazard situation. Prior to a biohazard incident, CCTV cameras can be used to monitor vulnerable infrastructure for suspicious activity. If the biohazard agent causes an immediate physical reaction by people in the vicinity of the release (e.g., biological toxin such as sarin or ricin), CCTV cameras may be useful in remotely assessing the situation. CCTV cameras can be used to monitor the progress of the emergency response and to enhance security at access points to the scene.

CCTV cameras have pan, tilt, and zoom features that allow operators to zoom in a notice small details. Some cameras have alarms, which can be configured in a variety of ways, and can be used to monitor any changes in the picture being captured by the camera. CCTV camera images can also be recorded and archived. The benefit of this would be to review the video later to determine how, when and where the biological release occurred or to evaluate the emergency response and clean-up of the incident. CCTV cameras do not have to be in fixed positions; they can be mounted on trailers and transported to the scene of the incident.

Video Image Processing (VIP) is a type of detection technology that can be used to detect vehicles by monitoring specific points in a video image. Vehicles are detected by determining if there are changes between successive frames in the video. This type of technology can be used to detect suspicious activity at vulnerable infrastructure as well as to monitor congestion. CCTV cameras can be equipped with VIP capability giving operators the ability to switch back and forth between detection (using VIP) and verification (using CCTV).

Roadway Detectors are used, during the response phase, to determine the volume, occupancy, and speed of vehicles on the roadway to monitor congestion and delay. Detectors, depending on the type, can either be mounted in the pavement or along the side of the road. With respect to a biohazard incident, transportation officials can use the data collected by detectors to determine how to re-route traffic around the affected area and to monitor for secondary incidents on alternate routes.

Infrastructure Monitoring Sensors are sensors that monitor the integrity of building structures such as tunnels and bridges. Infrastructure monitoring sensors can be used to help prevent a biohazard incident by detecting the presence of stopped vehicles in tunnels or on bridges where a bioagent may be released.

Vehicle Probes are another technology that can be used to monitor traffic conditions in the roadway network. Vehicles probes can act as moving sensors to provide information regarding traffic conditions (vehicle speed and travel time). This information can be transmitted to a central computer system where it can be merged with other information to provide an accurate representation of real-time travel conditions. The following technologies are types of vehicle probes:

- *Geographic Positioning Systems (GPS)* consist of twenty-four satellites that continuously orbit the Earth. These satellites can locate any object on Earth that has a device capable of receiving the satellite signal. The position of the object is determined by measuring how long a radio signal take to reach the object from multiple satellites.

- *Automatic Vehicle Location (AVL)* technology enables the approximate location of a vehicle to be determined and tracked. Some AVL systems use a series of antennae to track the location of the vehicle as it passes, while other systems use internal maps to track a vehicle's location or determine location from a predefined starting point.

- *Automatic Vehicle Identification (AVI)* technology allows individual vehicles to be uniquely identified as they pass through a detection area. Roadside units with antennae detect the AVI-equipped vehicles. The information from the roadside unit is then transmitted to a central computer where the vehicle's location, speed, and travel time are tracked, thus acting as a vehicle probe.

- *Cell phone probes* use radio frequency receivers and triangulation techniques to determine a vehicle's location based on cell phone usage. In conjunction with map-matching algorithms, vehicles can be tracked as they travel through the transportation network. Information that can be gathered from cell phone probes includes vehicle speeds and travel time.

The EPI-Center Deployment Following the 1994 Northridge Earthquake

The 1994 Northridge Earthquake caused considerable roadway and building damage disrupting traffic flow throughout Southern California. ITS technologies were deployed to supplement Los Angeles' Traffic Management Center (TMC) and were controlled by an operations center built specifically to manage post-quake operations called the Earthquake Planning and Implementation Center (EPI Center). The EPI Center coordinated traffic management deployments and gave traffic engineers accurate transportation information.

Numerous technologies were used to keep the transportation system functioning smoothly during the earthquake recovery. **Variable message signs** (VMS) were placed in the detour zones so information about traffic conditions, detours, and road closures could be relayed to travelers. Slow-scan **cameras** were used in conjunction with the VMS to ensure travelers responded to the messages. **Highway advisory radios** and dynamic advance warning signs were jointly used to notify travelers of approaching delays or incidents. **Sensors** imbedded in the pavement provided real-time volume and estimated speed data throughout the region. **Video image processing systems** (VIPS) were used to collect instantaneous traffic data near viaducts. Satellites were used to establish **wireless communications** links between the field equipment and the central system.

Source: Innovative Traffic Management Following the 1994 Northridge Earthquake, U.S. DOT

All of these types of vehicle probes can be helpful during a biohazard emergency. These probes can be used to monitor travel time, speed, congestion, and delay on routes outside of the area affected by the biohazard to identify alternate routes and to monitor for secondary incidents. They can also be used to track and manage emergency response, transit, and maintenance vehicles responding to the incident. Knowing the locations of these vehicles, transportation officials can help to facilitate the movement of these vehicles from the scene to staging areas or medical facilities.

Although *video wall* technology cannot be used in the field like the other technologies identified, it is an important technology, because it allows transportation officials to view and monitor the images being transmitted by CCTV cameras. A video wall allows officials in a transportation command center to view multiple images, documents, and programs all at the same time. For example, officials could view video images and a GIS map of the roadway network at the same time to determine where to position barriers or to identify viable alternate routes.

4.1.2. Communications

Communications Technologies
▪ Mobile Communications ▪ Mobile Data Terminals ▪ Computer Aided Dispatch ▪ C2C Communications ▪ C2F Communications ▪ Emergency Alert System ▪ MayDay System

Mobile Communications include two-way radios, cell phones, and satellite telephones. By having mobile communications, responders at the scene can communicate with officials at staging areas or in incident or transportation management centers to organize resources for the response. In addition, if interoperable equipment is used, multiple agencies can communicate with one another, thus facilitating interagency coordination.

Satellite telephones provide voice communications in areas not covered by cellular or landline telephone through the use of satellites for transmission. During a biohazard incident, cellular and landline telecommunications could become overburdened with calls. By having redundant satellite telephones, all involved stakeholder agencies would be able to communicate in order to provide the appropriate response.

Mobile Data Terminals (MDTs) are small computers installed in emergency response vehicles that allow vehicle operators to transmit information such as incident reports and photographs back to transportation management or incident command centers wirelessly. As with mobile communications, MDTs are crucial during the response to a biohazard incident. By being able to send photographs and data reports from a vehicle at the scene to a command center, transportation and emergency response officials outside of the scene can get a better understanding of the type and severity of the incident and can therefore organize a response that is better suited to the situation.

Computer Aided Dispatch (CAD) is a computer system that can be used to dispatch personnel and vehicles to an incident. The system can track and prioritize information related to vehicle dispatch and can be linked to MDTs in emergency response vehicles or interfaced with AVL. This type of technology can be helpful during a biohazard incident in order to dispatch only the minimal number and correct type of vehicles needed at the scene, thus ensuring an efficient response and reducing the exposure of the other vehicles. In addition, CAD, in conjunction with AVL / AVI, can be used to identify the vehicles that need to be decontaminated and track the decontamination process for each vehicle.

Washington State Patrol's Computer-Aided Dispatch System

Washington State recently worked with U.S. DOT to test and implement a new **computer-aided dispatch (CAD) system**. The new system is tied to Washington DOT's Condition Acquisition and Reporting System (CARS), which allows government officials to monitor the state's transportation system. CARS is also used to supply some information to travelers, such as delays, weather conditions, road incidents. By connecting the two systems, public safety officials can instantaneously access road conditions, allowing them to make more informed decisions when dispatching emergency responders.

Within a minute of an event registering in the CAD system, the CARS system will issue a filtered report to transportation officials. The report is filtered to protect any private information about the incident, while still allowing transportation officials to understand potential impacts of the incident. This CARS-CAD system link also allows emergency responders to access traffic, construction and weather information on the highways before traveling to the site of an incident. The responders can adjust their trip to the site or back to the hospital based on information in CARS.

Source: U.S. DOT ITS Joint Program Office

Center-to-Center (C2C) Communications involves direct system-to-system transmission of data and commands through computers between two transportation management centers (TMCs) or agencies. The use of C2C communications is important for keeping all involved agencies informed during a biohazard situation. The center "in charge"(probably an incident command center) can be responsible for getting updated reports from the field, and then transmitting that data to other centers (such as transportation management centers) via C2C communications. The advantage of C2C communications is when the information is transmitted to another center, it can be viewed via the central software system (such as an ATMS) and integrated with other information already in the system.

Center-to-Field (C2F) Communications involves direct communications from field devices to computers in transportation management centers (TMCs) or agencies. C2F communications are used to transmit vehicle count, occupancy, and speed data from detectors to TMCs. This type of communications can be used during a biohazard incident to allow communication with CCTV cameras, highway advisory radio (HAR), variable message signs (VMS), vehicle probes and mobile data terminals.

Emergency Alert System is a broadcast system used to warn the public about emergency situations. During a biohazard emergency, this type of system can be used to communicate quarantine or evacuation orders to the public as well as other information about the incident.

The *MayDay System* gathers information from wireless enhanced 911 systems, roadside call boxes, mayday and automated collision notification systems to help transportation and emergency services personnel identify incidents quickly. During a biohazard incident, a MayDay system can be used as a tool for gathering information from the public to detect an incident.

4.1.3. Traveler Information

Variable Message Signs (VMS) are signs that electronically vary their visual display as traffic conditions warrant. Normally transportation officials use these signs to provide information to the public regarding incidents, construction, congestion, or AMBER Alerts. During a biohazard emergency, these signs could be used to broadcast evacuation or quarantine orders, road closures, alternate routes.

Traveler Information Technologies
▪ Variable Message Signs ▪ Highway Advisory Radio ▪ 511 Traveler Information Phone System / Website ▪ Trailblazing Signs ▪ Parking Lot Information Systems ▪ Bus / Train Arrival Signs ▪ In-Vehicle Navigation Systems ▪ Kiosks

Travel time signs are variable message signs that are used to display travel times between two points that are determined through the use of detectors. During a biohazard emergency, this information can be used by drivers to determine whether to maintain their current route around the incident or chose another alternate route.

Highway Advisory Radio (HAR) is a traffic information broadcasting system that provides information to travelers via a specific channel on the radio. HAR differs from VMS because HAR messages are not restricted in length and therefore more detailed information can be provided to the public. During a biohazard emergency, HAR could relay information to the public regarding the type of incident, expected duration, road closures, evacuation / quarantine orders, emergency shelter information (location and directions), information on alternate routes / modes, and information regarding the risks to public health caused by the incident.

511 Traveler Information Phone System / Website is an outlet for providing information to travelers before they begin their trips. The information that can be provided by a phone system / website can be very detailed and can include all the information that a HAR system can provide.

Use of ITS Technologies in Response to the September 11th Attacks

The events of September 11 had significant impacts on transportation facilities in New York and Washington. Within two minutes of closing the George Washington Bridge, technologies such as **highway advisory radio** (HAR) and **variable message signs** (VMS) were used to alert motorists to use alternate crossings. New York also closed some local streets near the World Trade Center, granting priority access to emergency vehicles. In Virginia and Maryland, the state DOTs coordinated traffic signals for peak periods and removed high-occupancy vehicle (HOV) lane restrictions to manage the heavy-outbound traffic caused by worried residents and employees leaving the city.

In addition to the immediate response, technology assisted travelers before they reached New York for days after the events. Surrounding states used HAR and VMS to alert motorists to avoid the New York and Washington regions. Travelers and freight transporters as far south as Delaware were notified to detour New York City if traveling north to New England. Notifying travelers far in advance allowed them to avoid delays and plan alternate routes.

Source: FHWA, A Guide to Updating Highway Emergency Response Plans for Terrorist Incidents – Contractor's Final Report, May 2002

The role of ITS in the AMBER Alert Plan

The AMBER Alert Plan was created in 1997 after a 9-year-old girl was kidnapped and murdered. Since 1997, 14 states have instituted the AMBER Alert Plan, which includes issuing an urgent bulletin to ask the community to assist in finding the child. In addition to distributing the bulletin via the **Emergency Alert System**, which utilizes television and radio broadcast systems; states have begun to use **cell phones** and **variable message signs** (VMS) on highways to distribute the bulletin. (webpage)

Variable message signs that typically disseminate traffic information to drivers are used for AMBER Alerts to display pertinent information about the abducted child, abductor, or suspected vehicle. Central control software enables transportation managers to quickly select the variable message signs located closest to the abduction and immediately post the AMBER Alert bulletin to those signs first.

Since states have started using VMS as part of the AMBER Alert Plan, VMS have played an integral role in cases where an abducted child was safely returned. For example, in Texas' first implementation of the AMBER Alert Plan, VMS systems contributed to the successful rescue of an infant who was kidnapped from a Wal-Mart parking lot. The ability of VMS to provide short, informative messages easily seen by many motorists has contributed to the success of the AMBER Alert plan. The use of VMS for AMBER Alerts confirms that the technology is versatile and can be effectively used for non-traffic related incidents.

Trailblazing Signs are small signs erected on roads that are used to direct motorists to a particular business or place of interest (e.g., airport, transit station, etc). During a biohazard emergency, temporary trailblazing signs could be erected to direct the public to medical facilities, emergency shelters, and alternate routes around the incident.

Parking Lot Information Systems are tied to advanced traffic management systems (ATMS) to monitor the availability of parking. Because these systems are tied to ATMSs, available parking information can be disseminated to travelers via traveler information devices such as variable message signs, highway advisory radio or 511 telephone systems, thus reducing traveler frustration and congestion associated with searching for parking. During a biohazard emergency parking lot information systems can be used to direct drivers to park and ride lots in order to take transit and reduce congestion caused by the incident. These systems can also be used to tell drivers which parking lots are closed because they have been converted to staging areas.

Bus / Train Arrival Signs are variable message signs that are used to display the amount of time until the next bus or train arrives. If a biohazard emergency severely hampers the highway system or transportation officials encourage a mode shift, these signs can be used to keep travelers informed about the status of transit arrival. The use of these signs will help to provide an *organized* evacuation in instances where immediate evacuation is not necessary.. Informing travelers will reduce confusion and chaos.

In-Vehicle Navigation Systems are "Smart Car" applications for vehicles that utilize map databases and include route guidance, vehicle locations, and traffic information displays onboard cars and trucks. Currently, in-vehicle navigations systems can be used during a biohazard emergency to allow travelers to request the system to find an alternate route to their destination. This technology is beginning to evolve toward providing travelers with real-time road closure information. Currently, in-vehicle navigation systems have only evolved as far as using archived statistical transportation and accident data to predict congested routes and using this information to choose an alternate route. In the future, real-time information could be used to dynamically alter the route of the traveler around the affected area without the traveler having to request an alternate route.[1]

Kiosks are a computer terminal display located in a public area such as a shopping center, airport, rest stop, etc., giving real-time traveler information for the purpose of trip / route planning. Travelers planning a trip during a biohazard incident can view which roads are closed and obtain alternate route information from these kiosks.

4.1.4. Environmental Management

Environmental Detectors are sensors that monitor air and water quality. Current detection technology can not reliably detect bioagents in real-time, but in the future it may be able to do so.

Environmental Management Technologies
▪ Environmental Detectors ▪ Road Weather Information Systems (RWIS)

Road Weather Information System (RWIS) Stations are environmental stations used by transportation agencies to monitor weather data such as pavement temperature, air temperature, dew point, moisture, subsurface temperature, relative humidity, wind speed and direction and precipitation. Although RWIS technology can not currently detect bioagents in real-time, in the future the RWIS station's visibility capability may be able to detect an aerosolized release of a bioagent.

4.1.5. Traffic Management

Automatic Gate Systems are used to control the flow of vehicles into or out of a certain area such as a parking lot. During a biohazard emergency this type of technology is crucial for maintaining access control. Gate systems can be set-up at emergency access points and staging areas in order to allow authorized personnel to enter the area, but keep unauthorized personnel out.

Traffic Management Technologies
▪ Automatic Gate Systems ▪ Advanced Traffic Controllers ▪ Signal Preemption Technology ▪ Alternate Signal Control ▪ ATMS ▪ Variable Speed Limit Signs ▪ Ramp Meters ▪ Electronic Toll Collection ▪ Lane Use Control Signs / Reversible Lanes

Advanced Traffic Controllers (ATCs) are used to control traffic signals, ramp meters, and other ITS technologies. They contain enhanced features which allow for the use of traffic responsive control and signal preemptions. These types of controllers are crucial for the management of other ITS technologies. During a biohazard incident, ATCs can be used to initiate traffic adaptive or responsive signal control, to initiate an alternate fixed time signal plan, and to control the metering rates of ramp meters.

Signal Preemption Technology uses sensors in traffic lights and in-vehicles to detect an approaching emergency vehicle. This technology, which must be used in conjunction with Advanced Traffic Controllers, reduces the time it takes emergency responders to respond to an incident. In a biohazard situation where the bioagent release is detected immediately, this type of technology would allow emergency responders to reach the scene more quickly and thus contain the biological hazard more quickly, thus reducing its spread.

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[1] *Hitachi Group's Initiatives Regarding Trends in Vehicle Information Systems*. Dr. Takieki Alzono, Hitachi Review Volume 53, No. 4, 2004.

Alternate Signal Control includes the following:

- *Fixed-Timing Traffic Software* – This type of timing software uses cycle and phases of predetermined length and cannot respond to short-term demand fluctuations. Fixed-timing software may consist of multiple timing plans based on the time of day, day of week, or holidays.
- *Traffic Adaptive Software* - Adaptive signal control systems coordinate control of traffic signals across a signal network, adjusting the lengths of signal phases based on prevailing traffic conditions
- *Traffic Responsive Software* – Traffic responsive control responds current traffic conditions through the use of inputs such as vehicle actuation, future traffic prediction, and pattern matching.

During a biohazard emergency, transportation officials could either use an alternate fixed-timing signal plan or use traffic adaptive or responsive to respond to the traffic conditions being experienced. Using alternate signal control will allow traffic to flow more smoothly and reduce congestion during an evacuation or on detour routes.

Advanced Transportation Management Systems (ATMS) are regional systems aimed at optimizing traffic flow for a set of roads or an entire region. Elements of ATMS systems include sensors to monitor traffic flow, centrally programmable traffic signals, automated highway signs, computers and telecommunications technology. ATMSs allow transportation officials to manage the transportation system remotely and to track all information about the transportation system in one place. In a biohazard situation, ATMSs would allow transportation officials to track information about the incident from all sources, adjust signal timings and collect data from detectors in order to monitor congestion, delay, and secondary incidents.

Variable Speed Limit Signs use sensors to monitor prevailing traffic and/or weather conditions, posting appropriate enforceable speed limits on variable speed limit message signs. For a biohazard emergency, variable speed limits can be used during evacuations or during periods of high congestion to force traffic to slow down and thus reduce secondary incidents.

Washington, DC, Emergency Traffic Signal Timing Exercise

At 9:50 pm, 15 minutes after the 2005 Fourth of July fireworks ended in Washington, DC, Operation Fast Forward was set in motion to test the city's emergency **traffic signal timing** for selected emergency evacuation routes. More than 125,000 vehicles were expected to travel downtown for the festivities. The test lasted 45 minutes and covered 10 traffic signal cycles. Green lights were lengthened from 70 seconds to three minutes and red lights were lengthened from 30 seconds to one minute along seven evacuation routes, known as E-routes, which officers directed motorists towards. The only snag along the E-routes was at 12th Street and Constitution Avenue NW, where traffic barriers were placed by U.S. Park Police to allow pedestrians to leave safely. By 10:30 pm, traffic was moving smoothly. The drill ended at 10:35 pm.

The E-routes were chosen two years ago as part of the government's response to the September 11th attacks. After concluding that a citywide evacuation is impossible, officials have focused on effectively moving smaller groups from specific locations. Transportation officials observed the evacuation from the **command center** at Reeves Municipal Center on 14th Street NW, watching televised images from about 50 **traffic cameras**. DC was the first major city to conduct such an exercise which was intended to show how the city's transportation system is affected during an emergency.

Sources: DC Department of Transportation, Washington Post

Coolidge Bridge Advanced Traffic Management System (ATMS)

The Massachusetts Highway Department (MHD) developed an **Advanced Traffic Management System** (ATMS) to combat traffic issues arising from reduced bridge capacity during the reconstruction of the Coolidge Bridge from 2001 to 2003. The goals of the system were to minimize congestion, alert the general public to traffic interruptions, and, most importantly, to allow emergency vehicles to cross the bridge without delay. In order to accomplish these goals, the ATMS utilized **variable message signs** (VMS), **closed-circuit television cameras** (CCTV), and the ability to manually operate the traffic lights in the vicinity of Coolidge Bridge.

Information on the traffic flow around the bridge's three intersections is transmitted to the traffic operations center (TOC) via **CCTV** and **automatic traffic detectors**. This information is disseminated to the public through strategically placed VMSs, and pre-trip information can be accessed through an affiliated **website**. Trained operators can alleviate congestion by setting traffic signals around the bridge to calculated settings. This is also utilized to assist emergency vehicles traveling to the Cooley-Dickinson Hospital. The TOC constantly monitors emergency radio frequencies, and can speak directly with emergency service personnel when they are attempting to cross the bridge, allowing the TOC to clear the bridge of stopped traffic during an emergency.

Sources: US DOT, UMass Amherst, Franklin Regional Council of Governments

Ramp Meters have traffic signals that alternate between red and green signals to control the flow of vehicles entering the freeway. For a biohazard incident, the ramp metering rate can be set to flush out the network, can be set to space cars farther apart in order to improve traffic flow during an evacuation or can maintain a red signal to tell motorists the ramp is closed.

Electronic toll collection is a system that uses a transponder / toll plaza telecommunications devices to enable vehicles to pay tolls with less delay at tollbooths. During an evacuation, transportation officials may decide to temporary suspend tolls. In order to do this, toll booth gates must be disabled in order to allow vehicles to flow through without paying. Electronic toll collection technology can be helpful for doing this remotely.

Lane-Use Control Signs / Reversible Lanes. Lane-use control signs are distinctive rectangular signals mounted above each lane displaying symbols intended to guide motorists into the appropriate lanes and direction of traffic flow on the freeways. (Reversible lanes allow travel in the peak direction during rush hour.) For biohazard incidents, lane use control signs can be used to close a lane for emergency response / transportation personnel only or reversible lanes can be designated for this type of traffic only. Doing this would facilitate travel by emergency response / transportation personnel.

4.2. Matrix: Tactical Operations & Management Activities vs. ITS Technology

Figure 2 is a matrix that maps the operational and tactical management activities (identified in Section 3) to the communications and ITS technologies (identified in Section 4.1) that can be used during an emergency response to a biohazard incident. The "Functions" column in Figure 2 lists the general operational activity. The "Operational Aspect" column lists the more specific operational activity. The "Tactical Operations and Management Activities" column lists a more detailed description of the types of activities that can be supported by the technologies listed in the "ITS technology" column.

Figure 2: Matrix of Tactical Operations & Management Activities vs. ITS Technology

Functions	Operational Aspect	Tactical Operations & Management Activities	ITS Technology
Communication	Use a common emergency communications system.	▪ Verify and relay information about the incident.	▪ Mobile Communications ▪ Emergency Alert System ▪ MayDay System
	Establish direct connectivity between stakeholder agencies.	▪ Share data between TMCs and incident command centers.	▪ Center-to-Center communications
Initial Identification, Verification, & Response	Verification of the incident.	▪ Surveillance ▪ 911 Reports ▪ Field Reports from Responding Agencies ▪ Service Patrol Reports ▪ Detection	▪ CCTV cameras ▪ Environmental detectors ▪ RWIS stations ▪ Infrastructure monitoring sensors
	Dispatch of emergency responders.	▪ Assess the incident. ▪ Assess the transportation network surrounding the incident. ▪ CCTV surveillance ▪ Field Reports from Responding Agencies ▪ Service Patrol Reports ▪ Detection ▪ Probe information	▪ CCTV cameras ▪ Video image processing ▪ Traffic detectors ▪ Vehicle probe technology ▪ Mobile data terminals ▪ CAD
	Classification of the incident.	▪ Using the four Emergency Activation Levels (Traffic Incident, District-wide emergency, Region-wide emergency and major emergency) classify the incident.	▪ CCTV

Functions	Operational Aspect	Tactical Operations & Management Activities	ITS Technology
Initial Identification, Verification, & Response	Activate protocols for stakeholder notification.	▪ Call Trees ▪ Incident information hotlines ▪ Stakeholder wide communications systems ▪ Email and pager alerts	▪ Center-to-center communications ▪ ATMS ▪ Emergency Alert System ▪ May Day System
	Activation of incident command structure.	▪ Notify all relevant stakeholders of the activation by phone, pager or email alert.	▪ None
	Use surveillance to survey affected areas.	▪ Fixed surveillance ▪ Portable surveillance	▪ Fixed traffic CCTV cameras ▪ Other security and CCTV cameras located in the affected area ▪ Portable CCTV cameras
	Activation of the Emergency Operations Center and assignment of stakeholder personnel to the center.	▪ Centralize communications and operations. ▪ Initiate incident tracking system.	▪ Center-to-center communications ▪ ATMS ▪ Mobile data terminals ▪ Video wall.
	Activate incident management / evacuation plans.	▪ Notify all relevant stakeholders of the activation by phone, pager or email alert.	▪ None
	Initiate statewide communications system.	▪ Interoperable communication between stakeholders.	▪ Mobile communications ▪ Satellite telephones ▪ May Day System
	Activate shared operations protocols.	▪ Shared control of central and field equipment.	▪ ATMS ▪ CCTV cameras ▪ Variable message signs ▪ Highway advisory radio
	Notify bus, railroad and trucking companies, aviation authorities and other transportation agencies.	▪ Email / pager alerts. ▪ Call the companies. ▪ Emergency Alert System.	▪ None

Functions	Operational Aspect	Tactical Operations & Management Activities	ITS Technology
Initial Identification, Verification, & Response	Initiate protocols for special populations.	▪ Transport the elderly and disabled to safe locations such as emergency shelters. ▪ Initiate school evacuation plan and move children to a safe location. ▪ Locate the parents of school children and deliver children to their parents rather than to their homes. ▪ Transport inmates from the facility affected to another secure facility. ▪ Provide decontamination or medical attention for the disabled, elderly, school children or inmates that are affected by the incident.	▪ None
	Based on incident assessment, coordinate assets, resources and equipment for multi-agency response.	▪ Determine the most appropriate assets (based on the type and location of the asset) for response.	▪ Vehicle probe technology ▪ CAD
	Identify key transportation facilities that will be used during the incident.	▪ Fleet management. ▪ Locate facilities that can be used.	▪ CAD ▪ Vehicle probe technology
Restricted Mobility & Access	Establish and manage emergency access.	▪ Establish emergency access through the use of barricades. ▪ Use checkpoints to allow emergency personnel and other responding stakeholders to enter and exit the incident location.	▪ Vehicle probe technology ▪ Automated gate system

Functions	Operational Aspect	Tactical Operations & Management Activities	ITS Technology
Restricted Mobility & Access	Detour traffic (outside of the quarantined area) and provide incident information to local residents.	▪ Detour traffic using field devices, 511, the Internet and commercial radio and television, reverse 911, AMBER Alerts and emergency responder personnel	▪ Portable / Permanent Variable Message Signs ▪ Trailblazing signs ▪ Portable / Permanent Highway Advisory Radio
	Use ramp control to close ramps to highways in the affected area.	▪ Put ramp meters on red.	▪ Ramp meters ▪ Traffic controllers
	Use alternate traffic control.	▪ Employ specialized traffic signal timing plans. ▪ Coordinate signals. ▪ Use traffic adaptive control. ▪ Use traffic responsive control.	▪ Advanced traffic controllers ▪ Fixed timing software ▪ Traffic adaptive software ▪ Traffic responsive software
	Provide buses for transit users outside the affected area to reach their destination if transit lines are closed or service is suspended.	▪ Provide spare buses.	▪ Bus / Train arrival signs.
	Coordinate delivery and security of resources for the public to the affected area including food, water and supplies and monitor the flow of these goods to ensure sufficient supplies are available.	▪ Set up special routes for delivery of materials to and from the incident site. ▪ Emergency access clearance. ▪ Ensure distribution of resources to the affected public.	▪ Vehicle probe technology. ▪ Lane use control / reversible lanes.
	Use spare transit vehicles or transportation vehicles to deliver supplies into the quarantined area.	▪ Provide spare buses or transportation vehicles.	▪ None
	Institute peak spreading.	▪ Encourage employers to allow alternate work hours or telecommuting ▪ Use congestion pricing to discourage use of the transportation network during peak periods or during the incident.	▪ Electronic toll collection.

Functions	Operational Aspect	Tactical Operations & Management Activities	ITS Technology
Restricted Mobility & Access	Limit use of the transportation network.	▪ Institute work hour restrictions. ▪ Institute curfews. ▪ Encourage voluntary "snow days." ▪ Use congestion pricing to discourage use of the transportation network during peak periods or during the incident.	▪ Electronic toll collection.
	Close ports and airports, suspend transit and intercity rail services.	▪ Inform the public.	▪ VMS ▪ HAR ▪ 511 ▪ Internet
Delivery of Prophylaxis	Coordinate with shippers / suppliers to determine the time required to procure and deliver resources to the affected area.	▪ Develop a schedule for resource delivery.	▪ None
	Coordination between TMCs, Federal agencies and public health officials to monitor the route and movement of the prophylaxis delivery truck from origin to destination.	▪ Use CCTV cameras and vehicle probe technology to monitor the route of the truck.	▪ Vehicle probe technology ▪ CCTV cameras
	Support the local distribution of prophylaxis by public health officials.	▪ Provide vehicles or personnel as needed.	▪ None.
	Expedite the arrival of prophylaxis.	▪ Close a lane with lane use control signs for use by prophylaxis delivery trucks only.	▪ Lane use control signs.
Evacuation	Use ramp controls and metering.	▪ Set ramp meters to flush out the network or space cars farther apart.	▪ Ramp meters ▪ Traffic controllers

Functions	Operational Aspect	Tactical Operations & Management Activities	ITS Technology
Evacuation	Use alternate traffic control.	▪ Employ specialized traffic signal timing plans. ▪ Coordinate signals. ▪ Use traffic adaptive control. ▪ Use traffic responsive control.	▪ Advanced traffic controllers ▪ Fixed timing software ▪ Traffic adaptive software ▪ Traffic responsive software
	Use variable speed limits.	▪ Use variable speed limit or static speed limit signs to reduce speeds near the incident zone, along evacuation routes or during heavily congested periods.	▪ Permanent or portable variable speed limit signs
	Encourage proactive diversions between networks.	▪ Provide traveler information pre-trip and en-route, including incident information and travel times, that encourages the public to use alternate routes.	▪ Highway Advisory Radio ▪ Variable Message Signs ▪ Travel Time Signs ▪ Bus / Train Arrival Signs ▪ Kiosks ▪ In-vehicle technologies
	Encourage mode shift to rail, transit, or bus based on the area affected.	▪ Add transit capacity by increasing the number of vehicles. ▪ Provide additional temporary transit service. ▪ Adjust headways to reduce the time because the arrival of buses at the most heavily used stops. ▪ Reduce transit fares to encourage a shift to this mode of travel. ▪ Transit trip planning hotline. ▪ Park and ride lots. ▪ Increase roadway tolls.	▪ Vehicle probe technology ▪ Lane use control signs ▪ Parking lot information systems. ▪ Electronic toll collection

Functions	Operational Aspect	Tactical Operations & Management Activities	ITS Technology
Evacuation	Modify roadway capacity by reducing capacity restrictions.	Provide additional capacity by: ▪ Removing work and construction zone barricades. ▪ Opening HOV lanes to all cars ▪ Removing HOT lane tolls ▪ Opening the shoulders. ▪ Using reversible lanes. ▪ For an evacuation, reverse lanes so they all move traffic in the direction away from the incident.	▪ Lane use control signs. ▪ Variable message signs. ▪ Reversible lanes.
Other Transportation Logistics	Close contaminated roads and infrastructure as well as parts of the transportation network not damaged but located in the affected area.	Close contaminated roads and infrastructure using: ▪ Barricades ▪ Emergency Responder personnel (police / fire) ▪ Service Patrols ▪ Other DOT personnel	▪ Portable / Permanent Variable message signs ▪ Portable / Permanent Highway advisory radio
	Deploy portable ITS equipment to monitor the incident and the response and to monitor and route traffic surrounding the incident.	▪ Traffic Detection equipment ▪ Environmental Detection equipment ▪ Surveillance equipment ▪ Traveler Information equipment	▪ Environmental detectors ▪ RWIS stations ▪ Biological sensors ▪ Video image processing ▪ CCTV cameras ▪ Variable message signs ▪ Highway advisory radio ▪ Trailblazing signs
	Implement strategies to facilitate access to the scene and to medical facilities by emergency responders.	▪ Open HOV / HOT / reversible lanes for emergency responder access to and from the incident site. ▪ Activate traffic signal preemption for emergency responders.	▪ Lane use control signs / reversible lanes. ▪ Variable message signs ▪ Traffic signals with preemption capabilities

Functions	Operational Aspect	Tactical Operations & Management Activities	ITS Technology
Other Transportation Logistics	Implement transportation contracts and emergency procurement capabilities.	▪ Use to quickly purchase supplies needed to respond to the incident. ▪ Use to replace damaged equipment after the incident.	▪ None.
	Route traffic and coordinate transportation service to bring affected citizens and the worried well to medical facilities.	▪ Establish acute care centers, emergency shelters and neighborhood emergency help centers. ▪ Use transit vehicles to move citizens to medical facilities.	▪ Trailblazing signs ▪ Portable / Permanent Variable message signs
	Keep neighboring jurisdictions informed of the status of the incident and coordinate traffic control strategies with them.	▪ Direct data feeds between TMCs ▪ Phone calls ▪ Email alerts ▪ Shared control	▪ Center-to-center communication ▪ ATMS ▪ MayDay ▪ Emergency Alert System ▪ Satellite telephones ▪ Mobile communications
	Manage wide-area transportation around the affected area.	▪ Detour routing. ▪ Ramp metering adjustments. ▪ Traveler information. ▪ Traffic control adjustments. ▪ Mode shift.	▪ Variable message signs. ▪ Highway advisory radio. ▪ Ramp meters. ▪ Traffic controllers. ▪ In-vehicle navigation systems.
	Monitor traffic flow in real-time.	▪ Surveillance	▪ CCTV cameras ▪ Video image processing.
	Incident, alternate route and travel time information pre-trip.	▪ Commercial television or radio. ▪ Emails / pager / PDA alerts	▪ Emergency Alert System ▪ 511 Traveler Information Phone Service / Website ▪ In-vehicle navigation systems ▪ Kiosks

Functions	Operational Aspect	Tactical Operations & Management Activities	ITS Technology
Other Transportation Logistics	Incident, alternate route and travel time information en-route.	▪ Commercial radio ▪ Field devices. ▪ 511 Traveler Information Phone Services ▪ Static detour signs.	▪ Highway Advisory Radio (HAR) ▪ Variable Message Signs (VMS) ▪ Kiosks ▪ In-vehicle navigation systems. ▪ Trailblazing signs. ▪ Travel time signs.
	Travel times and “next-bus” arrival information en-route.	▪ Dynamic signs	▪ Travel time signs ▪ Variable message signs ▪ Bus / train arrival signs
	Trip planning capabilities. (Roadway & Transit)	▪ Transit trip planning hotline. ▪ Internet transit trip planning tools. ▪ Internet roadway trip planning tools.	▪ 511 telephone / web-based trip planning service.
	Traveler information for commercial vehicles and shippers.	▪ CB Radio alerts ▪ Notify commercial vehicles at weigh stations.	▪ Kiosks ▪ Variable Message Signs ▪ Highway Advisory Radio
	Update information to the general public regarding the status of the incident, restrictions, closed roads / infrastructure, duration and treatment.	▪ Media (Newspaper, television, radio) ▪ Reverse 911. ▪ Amber Alerts	▪ Variable Message Signs ▪ Highway Advisory Radio ▪ 511 telephone / web service.
	Coordinate with shippers / suppliers to determine the time required to procure and deliver resources to the affected area.	▪ Develop a schedule for resource delivery.	▪ None
	Expedite the transport of high-priority materials to and from the contaminated site in order to remove contaminated material	▪ Set up special routes for delivery of materials to and from the incident site. ▪ Emergency access clearance. ▪ Close highways or lanes to expedite delivery.	▪ In-vehicle navigation systems. ▪ Vehicle probe technology ▪ CAD ▪ Lane use control / reversible lanes

Functions	Operational Aspect	Tactical Operations & Management Activities	ITS Technology
Other Transportation Logistics	Collect data from detectors to keep stakeholders up to date on the status of the transportation system and presence of secondary incidents.	▪ Service patrols. ▪ 911 reports. ▪ Surveillance ▪ Detection	▪ CCTV cameras. ▪ Traffic detectors ▪ Video image processing. ▪ Vehicle probe technology.
	Secondary incident monitoring.	▪ Surveillance	▪ CCTV cameras ▪ Video image processing
	Use lane use control to manage the flow of traffic.	▪ Emergency responder only lanes ▪ Removal of HOT / HOV restrictions ▪ Opening of shoulders	▪ Permanent or portable lane use control signs ▪ Variable message signs
	Assess air and water quality.	▪ Detection.	▪ Environmental detection ▪ RWIS stations
	Provide spare transit vehicles for the transport of infected patients as well as dead bodies to medical facilities.	▪ Use of spare transit vehicles.	None
	Perform damage assessments.	▪ Manual inspection. ▪ Surveillance ▪ Detection	▪ CCTV and Security cameras ▪ Infrastructure monitoring devices.
	Perform infrastructure repairs.	▪ Use on-call construction contracts to make emergency infrastructure repairs.	▪ None
	Decontamination & waste disposal.	▪ Decontaminate equipment, vehicles and personnel. ▪ Properly dispose of biohazardous waste and contaminated debris.	▪ None

Functions	Operational Aspect	Tactical Operations & Management Activities	ITS Technology
Other Transportation Logistics	Organize transportation and facilitate the movement and proper disposal of biohazardous waste.	▪ Use of transportation vehicles. ▪ Plan route and monitor delivery of waste to disposal site. ▪ Close lanes or roadways to expedite the disposal of waste.	▪ Lane use control signs / reversible lanes. ▪ CCTV cameras
	Restoration of the transportation system and re-entry.	▪ Remove barricades and open roads that were closed. ▪ Re-open the incident site. ▪ Facilitate re-entry into the area by opening shoulders, HOV / HOT lanes etc.	▪ Reversible lanes. ▪ Variable message signs. ▪ Lane use control signs.
Public Information	Provide information to the general public on the nature of the incident, precautions to take, restrictions, closed roads / infrastructure, duration and treatment for exposure.	▪ Press releases. ▪ Commercial television and radio. ▪ Field devices. ▪ Internet ▪ Newspaper. ▪ Reverse 911 ▪ 511 Telephone System ▪ AMBER Alerts	▪ Variable Message Signs ▪ Highway Advisory Radio ▪ 511 Traveler Information Phone System / Website ▪ Mobile Communications (text alerts, recorded alerts)
	Public reassurance.	▪ Keep the public informed via traveler information and press releases to the media.	▪ 511 Traveler Information Phone System / Website
After Incident Evaluation	Assessment of incident response.	▪ Review the procedures and protocols used. ▪ Have all involved stakeholders work together to determine what worked well and what didn't work well.	▪ None

Functions	Operational Aspect	Tactical Operations & Management Activities	ITS Technology
After Incident Evaluation	Assessment of detour routes.	▪ Review if the number of routes available was able to handle the demand. ▪ Determine if the appropriate routes were suggested. ▪ Evaluate other possible detour routes.	▪ None
	Revise incident response / evacuation plans.	▪ Use lessons learned from the incident to make changes to incident response and evacuation plans. ▪ Investigate new different procedures and protocols for incorporation into the plan. ▪ Distribute updated plans to all stakeholders.	▪ None

4.3. Assessment of Technology

As identified in Section 3.1, all of the technology options presented have an application to biohazard situations. This section will focus on the current availability and applicability of these options in small, medium, and large metropolitan areas as well as identifying which technologies are still emerging. In addition, the equipment needs, or functional requirements, of each type of technology will be examined.

4.3.1. Availability of Technologies / Emerging Technologies

In small metropolitan areas, many of the technology options presented are not currently being used. Many have deployed trailblazing signs, but at the present time most small metropolitan areas are focusing on upgrading signal systems. Upgrades include replacing old controllers with advanced traffic controllers (ATCs), interconnecting signals, and installing fixed-timing or adaptive traffic control software. Most small metropolitan areas do not experience the daily recurring congestion and delay that would warrant the establishment of a transportation management center or installation of field devices such as variable message signs or detection. However, all metropolitan areas are engaged in incident management on a daily basis and therefore have technologies related to incident management, such as preemption and CCTV cameras. The Emergency Alert System was established by the Federal Communications Commission in 1994 and is deployed in all metropolitan areas.

Most medium-sized metropolitan areas have fully deployed signal systems and are concentrating on operations at a transportation management center (with an ATMS and video wall) and the deployment of field devices such as detectors, variable message signs, HAR, and CCTV cameras. Automatic gate systems are widespread as part of parking lot payment systems; however, parking lot information systems are not as widely available in medium-sized metropolitan areas. Some medium-sized metropolitan areas may use vehicle probe technology such as AVI or AVL in service patrol, maintenance, or transit vehicles, but most are only using this type of technology for dispatching with a CAD system rather than using the information provided by these probes to monitor the congestion and delay of the transportation network.

Large metropolitan areas are by far the most progressive in the use of ITS technologies. For the most part, large metropolitan areas have been deploying ITS equipment longer and therefore have completed or are in the process of completing the instrumentation (deployment of field devices) of their major routes. Many large metropolitan areas are now moving toward using vehicle probe information to monitor congestion and delay and actively operating the transportation network by providing travel times and suggesting alternate routes.

Most large metropolitan areas have a 511 traveler information telephone systems and websites as well as electronic toll collection and RWIS stations for gathering weather data. Parking lot information systems are starting to become more prevalent and some large metropolitan areas have recognized the benefits of ramp metering and installed this technology. Transit operations are also advanced in large metropolitan areas. Transit operators provide bus and train arrival signs as well as operate their system using CAD and vehicle probe technology in order to increase adherence to schedules.

Center-to-center communications, although a well known concept, is still emerging in all metropolitan areas. These areas are just starting to recognize the benefits of interconnecting transportation, emergency response, and other stakeholders and installing these C2C links. Satellite telephones are also an emerging technology. It was once commonly believed that cellular telephones were sufficient for incident management; however, it has recently become clear that cellular telephone service can be disrupted or overwhelmed during an emergency. Satellite telephones, although more expensive, offer increased reliability..

Vehicle probe technology has been around for some time, but large metropolitan areas are just starting to use this technology for congestion management. In-vehicle navigations systems are mainly deployed in high-end cars and are still evolving from static to dynamic systems; thus, this type of technology is not yet widely available. Variable speed limits and lane-use control signs are also less widely deployed.

Environmental detection technology can be used to measure weather information, but the technology for quickly and reliably detecting biohazard releases is still under development. As this technology improves, it may provide transportation and emergency responders with more efficient and effective methods for detecting biohazard agents.

4.3.2. Matrix: Assessment of Equipment Needs & Specifications for Preferred Options

For each of the technologies identified, there are specifications that each must meet to be effective for traffic and incident management as well as for use during a biohazard incident. Figure 3 lays out the specifications for each type of technology presented in this report. These specifications include functional requirements, location and deployment density, frequency of collection, accuracy, and other characteristics. These specifications mirror those that State DOTs and other transportation stakeholders are currently using for these technologies. These existing specifications were determined to be sufficient for biohazard situations.

Figure 3: Assessment of Equipment Needs & Specifications for Preferred Options

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
Surveillance & Detection				
CCTV Cameras & Video System	▪ Shall provide full motion video. ▪ Shall provide color and monochrome images. ▪ Shall include PTZ with local and remote control ▪ Shall be NTCIP compatible (1201,1205) ▪ Shall provide clear day and night video. ▪ Shall be configurable for operator privileges for viewing and PTZ. ▪ Shall provide automatic and manual day-night switch over technology (color to monochrome). ▪ Shall provide automatic white balance and automatic iris control with manual override. ▪ The camera enclosure shall be environmentally resistant and include a sun and drip shroud. ▪ The camera enclosure shall include a heater, defroster and adjustable thermostat. ▪ The camera shall include surge protection equipment. ▪ The pan-tilt unit shall provide	▪ Full or new full coverage for evacuation routes ▪ Full coverage of critical infrastructure	▪ 1 frame every 5 seconds, minimum on evacuation routes. ▪ Full motion video and high speed network from critical infrastructure	▪ Broadcast quality for critical infrastructure

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
	vertical movement of + or – 90 degrees and horizontal movements of 350 degrees. ▪ Pan & tilt movement shall be fast; at least 100 degrees / second. ▪ Ambient temperature range shall be -20 to 50 degrees Celsius, minimum ▪ Relative humidity range shall be 5-95% non-condensing. ▪ Shall provide software-programmable presets. ▪ Shall provide software-configurable privacy zones. ▪ System shall allow multiple display of images to multiple viewers. ▪ System shall provide “ownership” rites to users to prevent “stealing” of camera control from a user.			
Video Image Processing	▪ Detectors shall be able to perform accurately in all environmental conditions including wind, fog, rain, extreme temperatures and all types of lighting ▪ Detectors shall be able to measure volume, occupancy and speed of vehicles. ▪ Detectors shall be able to detect stopped vehicles	1 mile spacing, maximum on evacuation routes ▪ Full coverage on critical infrastructure including shoulders.	30 seconds ▪ 5 seconds maximum for stopped vehicle detection on critical infrastructure	Maximum error 10%

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
	▪ Detectors shall be polled for information every 30 seconds and this information should be transmitted into a daily file. ▪ Detectors shall be able to monitor multiple lanes of traffic. ▪ Detectors shall allow for the programming of preset detection zones.			
Traffic Detectors	Detectors shall be able to perform accurately in all environmental conditions including wind, fog, rain, extreme temperatures and all types of lighting. Shall have the ability to measure both stationary and moving vehicles. Detectors shall be able to measure volume, occupancy and speed of vehicles. Detectors shall have the ability to detect stopped vehicles.	▪ 1 mile spacing, maximum on evacuation routes ▪ Full coverage on critical infrastructure including shoulders.	▪ 30 seconds ▪ 5 seconds maximum for stopped vehicle detection on critical infrastructure	Maximum error 10%
Infrastructure Monitoring Sensors	▪ Shall remotely monitor infrastructure to detect changes caused by the environment or human tampering. ▪ Shall provide notification (alarmed) if changes are detected. ▪ Shall be linked to CCTV cameras	▪ At critical infrastructure locations.	▪ 1 second	▪ 5% error, maximum

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
	that can view the spot locations. ▪ Shall be compatible with ATMS.			
Vehicle Probe Technology	▪ Shall use conventional reader technology. ▪ Shall not identify personal information of the user. ▪ Shall use smart card technology. ▪ Shall identify vehicle, location, time of day and date, and speed.	NA	▪ 30 seconds.	▪ Maximum 10% error
Automatic Vehicle Location (AVL) & GPS	▪ AVL technology shall be able to identify the location of all transit vehicles. ▪ Shall provide information for computing arrival times, schedule adherence, and connection protection ▪ Shall provide information in all weather conditions.	NA	▪ 5 seconds, maximum	▪ 10% error
Automatic Vehicle Identification (AVI)	▪ Shall be able to provide vehicle identification and travel. ▪ Shall provide information in all weather conditions.	NA	▪ 5 seconds, maximum	▪ 10% error
Cell phone probes	▪ Shall not identify personal information of the user. ▪ Shall identify vehicle, location, time	NA	▪ 30 seconds	▪ Maximum 10% error

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
	of day and date, and speed.			
Video Wall	▪ Shall be compatible with ATMS. ▪ Shall allow CCTV images and CAD data to be displayed on the video wall. ▪ Shall display both graphic and video images. ▪ Shall be able to "window" multiple images.	NA	NA	NA
Communications				
Mobile Communication (2-way Radios, Cell phones)	▪ Communications channels shall be available to all transportation stakeholders. ▪ Communications shall not become overloaded or fail during an emergency.	▪ NA	▪ NA	▪ Maximum, 95% availability
Mobile Data Terminals	▪ Interface to wireless communication networks. ▪ Contain a full QWERTY keypad. ▪ Rugged enclosure. ▪ Interface with AVL, GPS technology and support job dispatch, text messaging and status reporting. ▪ Fully configurable. ▪ Provide graphical display with LED	NA	NA	▪ 90% availability

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
	backlight. ▪ Automatic status updating and event triggering.			
Computer Aided Dispatch	▪ Shall allow for customization. ▪ Shall track incident information and monitor field unit activity. ▪ Shall provide a user-friendly interface. ▪ Shall interface with other transportation management systems. ▪ Shall identify geographic location of call and report. ▪ Shall have caller identification.	▪ NA	▪ NA	▪ Maximum, 5% error
Center-to-Center Communication	• Shall support NTCIP 2306.	NA	NA	NA
Emergency Alert System	▪ Shall be able to sent out textual and audio alerts.	NA	NA	▪ 95% availability, minimum
MayDay System	▪ Shall detect accidents and incidents in rural locations. ▪ Shall alert an operator of an accident in real-time. ▪ Shall provide two-way voice communications between the	NA	NA	▪ 95% availability

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
	monitoring center and the vehicle.			
Satellite Telephones	▪ Shall provide hand-held or transportable satellite telephones. ▪ Shall be battery powered. ▪ Shall not require line-of-sight transmission. ▪ Shall be operable during any type of emergency. ▪ Shall be data capable. ▪ Shall have rugged enclosure for outdoor exposure.	NA	NA	▪ 90% availability
Traveler Information				
Variable Message Signs (VMS)	▪ The software shall communicate using Markup Language for Transportation Information (MULTI), as defined in the latest edition of the Joint AASHTO/ITE/NEMA Standards Publication TS 3.6, National Transportation Communications for ITS Protocol (NTCIP) Object Definitions for Dynamic Message Signs (DMS). ▪ There shall be text-centering, text right justification and text left justification options and appropriate spacing of letters and words.	▪ At critical junctions or decision points	NA	90% availability

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
	▪ Software shall control flash and alternating between pages of a two and three-page display. ▪ Software shall be able to display a static message. The message chosen shall be displayed constantly on the sign face until instructed to do otherwise. ▪ Signs shall be able to flash a message. A selected portion of the chosen message shall be displayed and blanked alternately at durations separately controllable in 0.1-second increments. ▪ Signs shall be able to produce multi-page messages. The chosen message shall display up to three different pages (each page consisting of up to three lines of text) alternately at durations separately controllable in 0.1-second increments. ▪ A computer shall be able to cause the controller to implement a particular display selected from the messages stored in its memory, or a new display sent from the computer using MULTI. ▪ The computer shall be able to edit or completely replace a message			

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
	stored in the controller’s memory. ▪ The computer shall be able to report the text of any message stored in its memory. ▪ Software shall check messages received and shall not change a message stored in memory or the display currently on the sign unless the message is received correctly. ▪ Software shall have the capability to manually change brightness. ▪ Communications shall be via polled multipoint operation, in which the sign controller informs the central computer of its current status in response to a query from the central computer. ▪ There shall be constant communications between each sign controller and the central computer. ▪ The central computer shall query each controller frequently about its current status in order to detect problems. ▪ The contents of the controller's memory shall be preserved during power interruptions and the controller shall resume complete operation automatically when power is restored.			

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
	▪ Upon recovering form a power interruption, the controller shall report to the central computer that it has just recovered from a power interruption. The software will display this status. ▪ Upon recovering from a power interruption, the software will have the capability to consult a configuration parameter set by the user to determine whether to blank its display or to display the message that it would have been displaying if no power failure had occurred. ▪ The software shall have separate configuration parameters for short and long power failures. ▪ There shall be a parameter specifying the maximum duration of a power failure classified as short. ▪ Test messages shall be stored in the controller's permanent memory. ▪ There shall be a text message that alternates the two previous displays at approximately ten second intervals. ▪ The software shall communicate using the National Transportation Communications for ITS Protocol (NTCIP). The software must adhere			

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
	to the version of the following standards that is current at the time of bidding, or a later version. ▪ Software shall be of design allowing users to monitor and control connected signs from the DMS computer in the Traffic Operations Center and also from workstations connected to the DMS computer by TCP/IP 100-Base T network. ▪ The user shall have the capability to see a list of messages stored in the sign, with an indication of which is currently being displayed. ▪ The user shall have the capability to cause a different message to be displayed. ▪ The user shall have the capability to view a display on the computer screen that shows exactly how the message will appear to motorists. ▪ The user shall have the capability to automatically detect malfunctions, including loss of communications. ▪ The user shall have the capability to create and edit messages, storing them on the DMS computer's disk drive for subsequent downloading to one or more signs. ▪ The user shall have the capability to			

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
	create an activity log for all signs. ▪ Software should have the capability to download a single message to multiple signs with a single command.			
Highway Advisory Radio (HAR)	▪ Shall use solar power with battery back-up. ▪ Shall allow broadcast of messages 3-5 miles away. ▪ Shall be able to program and change message remotely. ▪ Shall be able to store messages in a transmitter library. ▪ Shall be able to listen to transmitter on a back channel to verify its accuracy. ▪ Shall be accompanied by static sign with dynamic flashing beacons to notify motorists of a traffic alert message. ▪ Shall be able to remotely modify signal levels.	▪ In advance of decision or diversion points.	NA	NA
Trailblazing Signs	▪ Shall be highly visible in all types of light. ▪ Shall lead travelers to places of interest or provide detour routes.	NA	NA	NA

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
Parking Lot Information Systems	▪ Shall have the ability to be tied to an ATMS and traveler information devices. ▪ Shall consist of traveler information technology (i.e. variable message signs) to direct travelers to available parking. ▪ Shall consist of payment technology for parking payment. ▪ Shall be able to determine parking availability.	▪ Detection at each space for availability	▪ 1 minute	▪ 20% error
Travel Time Signs	▪ Sign shall include static text and variable text where travel times can be inserted. ▪ See requirements for variable message signs.	NA	NA	NA
Bus / Train Arrival Signs	▪ Shall display arrival times and bus or train (route) numbers in real-time. ▪ See requirements for variable message signs.	▪ At transit stops or stations	▪ 5 seconds	▪ 10% error
In-vehicle navigation systems	▪ Shall provide the following capabilities: trip planning, multi-mode travel coordination and planning, pre-drive route and destination selection, dynamic route selection, route guidance and route	NA	NA	NA

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
	navigation. ▪ Shall be interfaced with GPS technology. ▪ Shall be capable of receiving real-time traffic updates.			
Kiosks	▪ Shall be an interactive touch-screen device the can be used to access traveler information. ▪ Shall be capable of communication with the ATMS. ▪ Shall allow for remote management. ▪ Shall provide user friendly interface.	▪ At large generators such as employments centers, transit stations, airports, rest areas	NA	NA
Road Weather / Environmental Management				
Environmental Detectors (Air & Water quality)	▪ Shall be capable of monitoring air and water quality. ▪ Shall be compatible with ATMS.	▪ At critical locations like water supplies and high density population areas.	▪ 1 second	▪ Maximum 5% error
Road Weather Information System Stations	▪ Shall provide remote environmental monitoring. ▪ Shall be compatible with ATMS. ▪ Shall monitor pavement temperature, air temperature, precipitation, wind speed and direction, humidity, dew point and station pressure.	▪ At critical weather areas – spot located.	▪ 1 minute	▪ 10% error

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
	▪ Shall provide accurate information in all weather conditions. ▪ Shall provide predictive weather information such as time to freeze, etc.			
Traffic Management				
Automated Gate System	▪ Shall use identification technology to determine when to open the gates. ▪ Shall send alarms to operators upon any failure. ▪ Shall "report" its state (up, down, etc.) to a central system for an operator. ▪ Shall operate on a TOD and manual mode.	▪ NA	▪ NA	▪ 95% availability, minimum
Advanced Traffic Controllers	▪ Shall use Model 2070 controller. ▪ Shall allow for emergency vehicle or transit preemption.	▪ All signalized intersections	NA	NA
Preemption Technology	▪ Shall be configurable for emergency vehicle and / or transit preemption. ▪ Preemption activity from each intersection should be reported to the local controller and to the ATMS.	▪ Along evacuation and rescue routes.	NA	▪ 10% error

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
Fixed-Timing Traffic Software	▪ Shall allow for multiple fixed timing plans per intersection based on multiple event time-of-day (TOD), day-of-week (DOW) and holiday schedules.	NA	NA	NA
Traffic Adaptive Software	▪ Shall utilize peer-to-peer communications. ▪ Shall allow for user defined phase minimum and maximums. ▪ Shall allow the user to program the phase sequence and determine which phases can be skipped. ▪ Shall be fully functional at the local intersection controller during periods when there is no communication with central control.	NA	NA	NA
Traffic Responsive Software	▪ Shall allow for multiple timing plans per intersection based on multiple event TOD, DOW and holiday schedules. ▪ Shall respond to actuations on all approaches and at pedestrian signals. ▪ Shall allow for user to set a minimum green, green extension and maximum green extension.	NA	NA	NA

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
Advanced Traffic Management System (ATMS)	▪ Shall be capable of monitoring and communicating with field traffic controllers. ▪ Shall control and monitoring of variable message signs. ▪ Shall control and monitoring CCTV cameras. ▪ Shall have the capability to launch and monitor video image processing detection cameras. ▪ Shall have the capability to display ATMS graphics on video wall. ▪ Shall have capability to display CCTV camera images on video wall. ▪ Shall be scalable for adding additional field devices. ▪ Shall be capable of monitoring detectors. ▪ Shall include a database management system. ▪ Shall include an asset management component. ▪ Shall be able to detect and track incident and events.	NA	NA	NA
Variable Speed Limit Signs	▪ Shall be able to dynamically display a change in regulated speed limit. ▪ Shall be able to dynamically display speed limit for all lanes or specific	▪ ½ spacing, maximum, for individual lane speed limits (gantries) ▪ At normal MUTCD	NA	▪ Maximum 10% error

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
	lanes. ▪ Shall be able to display speed limits for specific users like trucks.	spacing for single speed limit		
Electronic Toll Collection	▪ Shall use a reader or antenna device to identify transponders / fare card media and charge travelers using DSRC communications. ▪ Shall provide passenger / vehicle count information. ▪ Shall be able to perform accurately in all environmental conditions including wind, fog, rain, extreme temperatures and all types of lighting and at all speeds. ▪ Shall provide capabilities for remote management of toll equipment.	NA	▪ NA	▪ 95% availability
Ramp Meters	▪ Shall meter traffic from on-ramp at computed intervals. ▪ Shall display command to drivers with 2-section traffic signal head (green & red) ▪ Shall be able to dynamically modify metering rates based upon conditions, ▪ Shall be able to be manually overridden. ▪ Shall allow a “flush” of queued traffic	NA	▪ 1 minute	▪ 10% error

Type of ITS Technology	Functional Requirements	Location / Deployment Density	Frequency of Collection	Accuracy
	based upon delay at the meters.			
Lane Use Control Signs / Reversible lanes	▪ Shall be able to dynamically display lane status (open, closed, closing, etc.). ▪ Shall provide display in both directions. ▪ Shall include barriers (see barriers above)	▪ ½ spacing, maximum, for individual gantries	NA	▪ Maximum 5% error

5. Conclusions & Recommendations

While all of the ITS and communications technologies mentioned above would be beneficial for traffic management and operations during a biohazard situation, some are critical and should be available to operators and responders. The SAIC Consulting Team recommends the following ITS technologies for application to biohazard situations:

- **Mobile Communications**. A common mobile communications platform is extremely important for managing all of the agencies involved in a biohazard incident including Federal, State and local emergency response, public health, DEC, HAZMAT and transportation agencies among others. In addition, it allows responders at the scene to communicate the status and resources needed to officials located at staging areas, and transportation and incident management centers.

- **CCTV Cameras.** CCTV cameras may allow agencies to remotely view and assess the scene of a biohazard release, reducing the time required to respond to the incident. In addition, CCTV cameras can help officials remotely monitor the response and “clean-up” process. CCTV cameras can also be invaluable for monitoring and managing the flow of traffic around a biohazard situation.

- **Mobile Data Terminals.** Similar to mobile communications, mobile data terminals allow responders on the scene to relay information to responders in stage areas or operators in transportation or incident management centers. However, mobile data terminals allow data reports and images to be sent to transportation or incident management centers. This is extremely crucial for providing images to officials outside the scene if there are no CCTV cameras within range for viewing the incident remotely.

- **Vehicle Probes.** Vehicle probe technologies such as AVL, AVI and GPS can improve both incident management and traffic management during a biohazard incident. By being able to track each individual vehicle on the scene, emergency response and transportation officials can better manage resources for the incident. In addition, vehicle probe technology can also be used to monitor the flow of traffic around the incident and on alternate routes. .

- **Traveler Information Technology (VMS / HAR / 511).** Traveler information technology is very important for ensuring that the general public understands that there is an incident, what the extent of the incident is, what roads are closed and what alternate routes should be used. VMS may be better than HAR because all vehicles that travel by a VMS see the message, whereas travelers can choose not to tune into the station broadcasting the HAR message. Similarly, 511 requires the user to be proactive and seek out information. However, VMS do not provide enough space to include all pertinent information regarding a biohazard incident. Therefore, each agency deploying these technologies for a biohazard incident needs to examine their intended audience and determine what the preferences are of their customer in order to determine which traveler information technology or combinations of technologies would be most effective.